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TRANSACTIONS

OF THE

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LATE

LYCEUM OF NATURAL HISTORY.

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1881-82.

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TRANSACTIONS

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NEW YORK ACADEMY OF SCIENCES.

October 3, 1881.

REGULAR BUSINESS MEETING.

Vice-President, Dr. B. N. MARTIN, in the chair.

Twenty-five members present.

After the transaction of business the members were invited, in accordance with the usual custom at the first meeting of the season, to present notes and observations recorded during the summer, and responses were made by Mrs. E. A. SMITH, Prof. C. A. SEELEY, and others.

Mr. W. L. CHAMBERLAIN referred to the gold deposits recently opened in Fulton and Saratoga counties, N. Y. The ore consists of auriferous pyrites and is contained in the gneiss of the foothills of the Adirondacks.

Remarks were made by a member, on a visit to the sandstone quarries at Portland, Conn.; by Mr. TODD, on a peculiar atmospheric phenomenon, a vaporous band stretching across the sky, apparently not auroral, observed in the Adirondacks; and by Dr. MARTIN, on a remarkable atmospheric coloration, luminous brilliance of the clouds, etc., observed last month at Saratoga, in the early morning, attributing it to an abundance of a smoky fog produced by the recent forest fires, and calling attention to the fact that this phenomenon has been noticed only in the territory east of the meridian of Saratoga.

Mrs. P. HANAFORD described the same appearances as seen during the "Yellow Day," Sept. 6, near Boston, and also on Nantucket; another member, as seen in the Genesee valley, explaining that the strong west and northwest winds prevailing at the time had wafted high in the air vast volumes of smoke derived from the abundant forest fires throughout Western N. Y.; Messrs. TODD, CHAMBERLAIN, and others, describing the electric brilliance of the gas-lights, the strange modification of the green color of foliage, the absence of smoky odor, etc., as observed at Great Barrington, Mass., and in less degree in New York city; Mr. N. L. BRITTON, on the same facts as observed several

miles out at sea, off Fire Island and Montauk Point, Long Island, N. Y.; Prof. D. S. MARTIN, as observed between Saratoga and Catskill, N. Y.; and Prof. C. A. SEELEY, calling attention to the extremely attenuated character of the carbon particles, produced by their long transportation from distant localities.

Mr. GEO. F. KUNZ mentioned that Mt. Mica, at Paris, Maine, the locality so famous for colored tourmalines for the last fifty years, had been purchased by a mining company and was being worked for cassiterite, mica and tourmaline, principally through the efforts of Dr. A. C. Hamlin of Bangor, Maine.

Dr. Hamlin has the finest known collection of American tourmalines, and he recently reported the discovery of a crystal three inches long and one-half inch thick, a transparent gem of a beautiful blue-green color. This was taken from the new mine, and many more remarkable specimens may be expected as the work advances.

Mr. Kunz said that during the last year a German agate-hunter returned to his native country after 20 years collecting in Brazil, taking with him a large suite of fine colored tourmalines, some five inches long and not more than one-eighth of an inch thick, transparent, and of a green color; also many fine green crystals with red, yellow, white, and other colored centres, many of these equalling for variety of color anything yet found, most of which will cut as gems. There is also in this lot one exceptionally fine green crystal over one inch square. This collector brought with him also at least 1000 kilos of transparent yellow spodumene, the same as that described by A. Pisani, of Paris, some eighteen months ago, and is dissimilar only in color to the new variety of spodumene found at Stony Point, North Carolina, described in the February number of the *American Journal of Science* for 1881, by Dr. J. Lawrence Smith, as Hiddenite. Some of the specimens which he brought will cut as fine yellow gems. All these were found in the Minas Geraes district. Recently a new locality for chrysoberyls has been found in Ceylon, where they occur of gem value in an unusual variety of colors, from yellow to brown, and from brown to green. The last color is the variety known as Alexandrite. This gem has heretofore been found but of very inferior size and color, but here it occurs of remarkable size, having in one case afforded a gem weighing 26 kts. They are a beautiful green color by day and a columbine red, or brownish red, by night. The chrysoberyl cat's eye is found here of the same color, and possessing the same dichroic property as the Alexandrite, viz., changing color, from green to red, and hence might very properly be called an Alexandrite cat's eye. Many of the chrysoberyls are erroneously called and sold as a variety of sapphire.

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October 10, 1881.

SECTION OF CHEMISTRY.

Vice-president, Dr. B. N. MARTIN, in the Chair.

Nineteen members present.

A paper was read by Mr. JAMES H. STEBBINS, Jr., of which the following is an abstract:

ON SOME NEW SALTS OF THYMOLE SULPHO-ACID, AND SOME NEW FACTS CONCERNING THE SAME.

60 grms. thymole were dissolved in 50 grms. 66° sulphuric, at a temperature of 100° C. The pink crystalline mass so obtained was dissolved in water, and converted into the lime salt.

Calcium Salt.—This salt crystallizes with two molecules of water, in rhombic plates, and shows under the polariscope a beautiful effect of circular polarized light.

Formula.

$$a\ (C_6\ H_2\ (C\ H_3)\ (C_3\ H_7)\ (O\ H)\ S\ O_3)_2\ Ca + 2H_2\ O.$$

a. Calcium salt of alpha thymole sulpho-acid.

Ammonium Salt.—This salt was obtained by decomposing the lime salt, with ammonic carbonate. It crystallizes in white rhombic plates, with 2 mols. of water.

Formula.

$$a\ C_6\ H_2\ (C\ H_3)\ (C_3\ H_7)\ (N\ H_4\ S\ O_3)\ a\ H + 2\ H_2\ O.$$

The sodium salt has likewise been obtained, and will be described in a subsequent paper.

Remarks were made by Mr. JAMES D. WARNER on the nature of the corona of the Sun, etc. Mr. STEBBINS reported the yellow coloration of the atmosphere in September at the Thousand Islands in the St. Lawrence.

October 17, 1881.

SECTION OF GEOLOGY AND MINERALOGY.

The President, Dr. J. S. NEWBERRY, in the Chair.

Fifty-one persons present.

Dr. NEWBERRY exhibited specimens of native lead and oxide of lead from a mine in the Wood river country, Idaho, crystallized gray copper, and fine crystallized rhodochrosite from the Ulay mines, Southwest Colorado.

Dr. T. EGLESTON pronounced the crystals of Rhodochrosite the finest he had ever seen, and probably the finest specimens ever yet found.

He stated to the Academy that since its adjournment in June he had made the discovery of tellurium in certain copper products from Colorado. The sample examined had been found to work unsatisfactorily and was supposed to contain arsenic and antimony, as the pig yielded dense white fumes in the furnace. After a careful examination no arsenic nor antimony was found, but nearly one half per cent of tellurium. The fumes poisoned the furnace, and the copper manufactured cracked in the rolls, was useless except for brass of poor quality, but was quite suitable for the manufacture of cupric sulphate. A number of ounces to the ton of silver and gold were found in the same copper, but too little to make a metallurgical separation possible.

Dr. Egleston also announced that after making a long series of examinations on the presence of silver in Lake and other brands of commercial copper, he had come to the conclusion that the silver was very unequally distributed in it; as assays taken fifteen minutes apart from several different charges, during the last two hours of the process while ladling, show the quantity to vary as much as eight or ten ounces in the different assays.

Dr. J. S. NEWBERRY remarked on:

GEOLOGICAL FACTS RECENTLY OBSERVED IN MONTANA, IDAHO, UTAH AND COLORADO.

Idaho and Montana.—The famous placers at Helena and Virginia, which have yielded thirty millions of dollars, are now exhausted, but vein-mining is in successful progress and yielding rich results at Butte, at the Alice, Lexington, Copper Bell, and other mines. These are true fissure veins, traversing a granite formation, and the speaker predicted their abundant yield of silver and copper twenty years hence. These territories have been simply crossed by two government expeditions and their resources have not been at all studied. It is the coming mining region, more discoveries of promising mines having been recently made here than in any other portion of the country. On the east of the mountains in Montana and Wyoming lies a fine agricultural country and excellent stock range, the herds ranging freely throughout the winters, in spite of their severity, with little loss, and grazing upon a native bunch-grass (*Festuca scabrella*) and the buffalo grass (*Buchloe dactyloides*). The climate is salubrious, the country very beautiful in many parts and very promising for emigration. In the adjacent Rocky Mountains range there are also many mining opportunities.

The remarkable lava plain, 400 miles long by 75 miles wide, in Central Idaho, was then described. Snake River, one of the chief tributaries of the Columbia, flows along its southern border for several hundred miles; its northern tributaries sinking under the lava sheet and flowing in subterranean channels 50 or 60 miles long. The rock is a basalt said

to contain every where a small quantity of gold and silver. It is generally covered with an impalpable soil that produces a dust excessively annoying to the traveler, and sustains a general growth of sage brush. In places, however, the rock is bare and looks like a congealed stormy sea. Three buttes are set on the surface of this lava plain, and each has probably been a local volcanic vent; but it is probable that most of this eruptive material has been an overflow from great fissures of which the position is not indicated on the surface. Snake River crosses a portion of this plain in a cañon, at the head of which are the great Shoshone Falls, 208 feet in vertical altitude.

An alluvial plain borders Snake River for 200 miles, abounding in black sand which contains much gold. This is, however, extremely fine, having been transported a long distance from its place of origin, and therefore difficult of separation. New and promising methods and machines are about to be tried in the exploitation of these extensive deposits. A wide mountain belt extends from the north side of the lava plain to and beyond the British line, and is apparently a good mining country throughout. Already a great number of productive and promising mines are opened in the southern portion of this belt. In the Wood River district the veins are not large, but numerous, regular and persistent, and the ore of high grade—mostly argentiferous galena, carrying $100 to $500 in silver to the ton. Near Challis, further north, is the celebrated Ram's Horn mine, located on a true fissure vein, generally not more than five feet wide, but continuous for more than five miles. The wall rocks are slate, the vein-stone siderite (carbonate of iron), the ore gray and yellow copper, yielding $100 to $1200 in silver to the ton. A few miles west of Challis is the mining town of Bonanza, where are located the celebrated Charles Dickens and Custer mines, carrying both silver and gold. Still further West in the Saw Tooth range, a high and very picturesque mountain chain running north and south, recent discoveries of valuable mines have been made. From this district north to the Canadian line, a broad mountain belt extends over northern Idaho and northwestern Montana, a country which abounds in veins of silver, copper and gold. Among the mines now worked in this region the most celebrated is the Drum Lomond, in Montana. It is opened on a large vein of rich quartz, and is owned by an old miner who cannot read, but who is said to have refused a million of dollars for the property. It is probably worth much more than this.

Most of the mountainous districts of Idaho and Montana are covered with coniferous forests, consisting of the Douglas spruce and the northern nut pine, *Pinus flexilis*. The smaller plants form an Alpine flora of much interest, including many beautiful flowering species;

perhaps the most striking being *Bryanthus*, which has a fine fir-like foliage and clusters of beautiful purple flowers. It belongs to the Heath family, and closely resembles the heather of Scotland.

The streams of this region are clear, cold, and rapid, and abound in fish, chiefly of the salmon family, and these have given the name to Salmon River, the principal water course.

Two species of salmon were running up the Salmon River, one the large Quinnat or Chinook salmon, comparatively rare, and the other the "red fish" (*Oncorhynchus nerka*). This is a small salmon, 15 to 18 inches in length, and weighing 3 to 5 pounds. As seen in their migration their bodies are brick red to purple in color, the heads dark or light green; they were then going up to their spawning ground, Redfish Lake, one of a half-dozen of small lakes on the headwaters of the Columbia, which are the special breeding-places of this interesting fish. Coming all the way from their abode in the ocean, led by an infallible but inscrutable instinct, they push on night and day till they reach their remote birthplaces in these little lakes far up in the mountains and 1000 miles from their starting point. Here they accomplish apparently the great object of their lives, the reproduction of the species, by depositing the spawn in the shallows of the rivulets which fall into the lake.

The always attractive coloring of the fish during this nuptial season becomes greatly heightened; the body assumes a brilliant, almost luminous red, as bright as that of the gold fish, and where numbers are dashing through the water, literally in a blaze of excitement, they produce an exhibition that is strikingly novel and interesting.

When the spawning season is over they probably do not return, as none are seen descending the rivers. The young fish start on their migration to the ocean while yet very small, and within the first year of their lives, remaining away it is supposed some three or four years, during which they acquire their full growth when they return to die where they were born.

An active industry has grown up in the capture of the red fish in their annual migrations, but it is pushed with so much energy and unsparing cupidity that their numbers are rapidly diminishing and the species will apparently be soon extirpated in these waters unless protected by legal enactment.

A branch of the Union Pacific Railroad is being constructed from Granger, Wyoming, to the mouth of the Columbia. On this a large amount of traffic is expected, as it will link together many settlements having a considerable resident population and traverse in different portions of the route rich agricultural and mining districts.

Dr. Newberry then briefly described a small but remarkably rich

placer gold deposit he visited on the west flank of Mount Wheeler, the highest mountain in Nevada, and mentioned the discovery of an outcrop of lower silurian rocks full of fossils, including several new trilobites, discovered by him in Southwestern Utah, but deferred all details till he should make them the subjects of special remark to the Academy.

Colorado.—Reference was made to the general character of Southwestern Colorado, the interesting topography of the region, especially the vast plateau which rises westward from the base of the Rocky Mountains on to the slopes of the Wahsatch ; the ascent of Marshall's Pass by the Denver. and Rio Grande Railroad, the most remarkable feat of railroad engineering performed in the country, and the exceedingly picturesque region about the Pagosa, the greatest hot spring on the continent. Where the San Juan River issues from the mountains a prairie occurs, surrounded by picturesque forest-clad hills, and with a beautiful view of snow-clad mountains in the distance. In the centre of the prairie lies a basin 40 by 60 feet across, boiling like a huge caldron, the ebullition being produced by the violent escape of carbonic acid gas. The banks are lined by the remains of beetles, snakes, etc., destroyed by too trustful reliance upon the hot waters, and by interesting mineral deposits. This is one of the most beautiful places in the country and likely to be a famous resort.

Along the route from Pueblo to Gunnison and Lake City, and thence eastward by Del Norte, there are some places of resort for invalids and pleasure-seekers, which are destined to be very well-known, being far more beautiful and salubrious than the now celebrated localities at Manitou and Colorado Springs. One of these is Wagon Wheel Gap, on the Rio Grande. The river is a rapid, turbulent stream, and the Gap is seven to ten miles long, just wide enough to permit a wagon-road. Then a wide, open space is reached, the basin of an ancient lake, girdled by a wonderfully beautiful amphitheatre of mountains. Here 8500 feet above the sea, the hot springs, charming rides, fine hunting and fishing, an atmosphere as pure and clear as crystal, constitute the attractions of a resort, which far surpasses any other, and which will be reached by the railroad now being pushed through the Gap about January 1, 1882.

From Gunnison, specimens have been recently brought of magnetite and hematite, which probably represent inexhaustible masses, and at Crested Butte, within twenty-five miles of this locality, is found the best coking coal in the West. The region borders on a volcanic area, and the coking coal is from that portion of the basin which has mostly escaped the alteration by volcanic heat. It is firm and not affected by the weather, with a small amount of ash and sulphur.

On Anthracite Creek are found many thousand acres of anthracite of better quality than that of Pennsylvania. Recent analysis made at the School of Mines, New York, shows it to contain less than one per cent. of sulphur, and three per cent. of ash.

The forest vegetation of Colorado is very simple. The pinion or nut pine is very common, also the yellow pine (*P. ponderosa*), Douglas' spruce, Menzies' spruce, etc. In the mountains the general vegetation is picturesque but not so varied as in the lowlands. The following plants are among the most characteristic in the lowlands of Colorado and Utah.

The evening primrose (*Œnothera Cæspitosa*), with its large beautiful white flowers.

The wild tobacco (*Nicotiana attenuata*).

The sun flower (*Helianthus*).

The bee flower (*Cleome integrifolia*), presenting purple acres by the roadside, and the yellow species (*C. lutea*) less common.

The American primrose (*Primula Parryi*).

The pasque flower (*Anemone patens, Var. Nuttalliana*).

The *Eriogonums*, about twenty species, coloring whole mountain sides yellow.

The Oregon grape (*Berberis aquifolium*).

Phacelia circinata, in tufts of purple flowers on rocky slopes.

The lily (*Calochortus Gunnisoni* and *C. Nuttalli*), or "black-eyed Susan" (Indian—"Seego"), very plenty in the moister portion of the sage-plains.

The clematis (*Anemone alpina*), with its purple flowers.

The penstemons, of which 20 or 30 species are peculiar to that county, deep crimson, pink, and purple and blue in color, often very showy, and so abundant that whole acres of ground are colored by them.

The columbine (*Aquilegia canadensis*), and also a much larger species (*A. cerulea*), clothing the mountains of Colorado and Utah, with blue, cream-colored, and white flowers. A large number of dried plants were exhibited from a collection of several hundred species just brought on from Colorado, with collections procured from Prof. Marcus Jones of Salt Lake City, and others.

October 24, 1881.

SECTION OF PHYSICS.

Vice-president, Dr. B. N. MARTIN, in the Chair.

Thirty-one persons present.

Mr. W. LE CONTE STEVENS read a paper, of which the following is an abstract.

WHEATSTONE AND BREWSTER'S THEORY OF BINOCULAR PERSPECTIVE.

For some time after the publication of Sir Charles Wheatstone's essay (1) in 1838, on the Physiology of Vision, this subject was studied with much zeal by Sir David Brewster, whose name is permanently associated with the lenticular stereoscope, an instrument now familiar in every household. Although the theories advanced by these two physicists to account for the illusion of binocular relief have since been shown insufficient, their mode of accounting for the estimate of distance as perceived in the stereoscope has been quite generally accepted. In 1844, Brewster published an essay (2) "On the Knowledge of Distance given by Binocular Vision," in which he elaborated and abundantly illustrated the idea that the apparent distance of an object is determined by the intersection of visual lines. The stereoscope had already been explained as an instrument by which rays of light from two slightly dissimilar pictures were made to enter the eyes, as if coming from a single object into which they are combined in front, and on each point of which the visual lines could be made to meet. Thus, in Fig. 1, if rays from the conjugate foreground points, A_1 and A_2, be

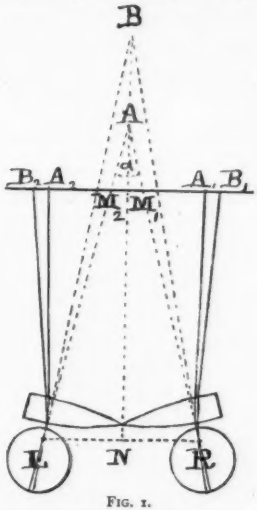

FIG. 1.

(1) Phil. Transactions, 1838, Part II.
Reprinted in Phil. Magazine, s. 4, vol. III., April, 1852.
(2) Edinburgh Transactions, vol. XV., Part III., p. 360.

deviated by the semi-lenses, they appear to have come from A. In like manner, the background appears at B. If i — interocular distance RL, and α — optic angle, then for the distance of A we have

$$D = \tfrac{1}{2}\, i \cot \tfrac{1}{2}\, \alpha$$

From this formula it is obvious that D ceases to have any positive finite value when the visual lines cease to converge.

If the semi-lenses be taken away, and A_1 and A_2 be removed to M_1 and M_2 respectively, while the convergence of visual lines remains unchanged, the images still appear at A and B. Wheatstone seems to have been the first to show experimentally that the illusion of apparent solidity can be obtained in this manner from a pair of projections representing the same object from slightly different points of view. If the eyes be properly trained, the visual lines may be directed to points whose distance is greater or less than that of the objects regarded at the same moment, and Brewster described many striking illusions thus obtained without the aid of the stereoscope. The principle applied by him, as described in the paper to which reference has been made, may be briefly given, and his results can be easily tested by any one who is accustomed to analyzing his own visual sensations. Upon a uniform horizontal surface (Fig. 2) let two lines, A C and B C, be drawn, form-

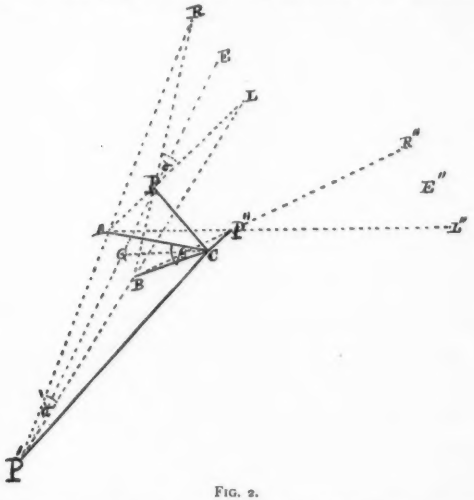

FIG. 2.

ing a small angle, β, with its vertex toward the observer. Let the eyes,

R and L, be placed above this. If they be directed to the point C, this appears in its true position. If the right eye be directed to B and the left to A, the axes meet at P; this point Brewster calls the binocular centre; and since the retinal images of B and A correspond, the visual effect is that of the union of these two external points at the binocular centre. Sweeping the glance toward C, the two lines appear united in the air, and P C is the apparent position of the combination, intermediate in direction between two monocular images, which may be disregarded or hidden from view with screens. If the convergence of visual lines be now diminished, the binocular image is lost until the right eye becomes directed to A and the left to B. The two points appear united at P', and the line P'C now appears in the air on the further side of the surface. If the convergence be increased till P is again the binocular centre, and the face be lowered and withdrawn till the eyes are at R'' and L'', then C P'' becomes the position of the variable external image. And if lowered until R''L'' coincides with the surface, C P'' vanishes at the moment of becoming coincident with the prolongation of G C, the median of the triangle A C B.

Brewster's formula for determining the distance of the binocular centre from G is easily deduced and applied.

Let i = interocular distance, R L.

" a = interval between the corresponding points, A and B.

" b = distance, G E, between card and observer.

" x = distance G P, or G P', which is positive when measured toward the observer, negative in the direction opposite. Then, observing the usual rule of signs, we have, by Geometry,

$$x = \pm \frac{a\,b}{i \pm a}$$

Applying this formula, Brewster constructed a table of distances for the binocular centre. For negative values it is seen that x becomes infinite when the visual lines become parallel; and, if they be slightly divergent, the binocular centre is far in the rear of the observer. Either of these conditions would make binocular vision impossible if the theory be correct. In testing the experiment with trained eyes, it is found quite possible to secure binocular fusion of the images of A and B when the interval between these points equals or slightly exceeds the interocular distance. It is also found that fusion of the images of the whole line at any given instant is impossible, especially when the angle β is large, or the lines are viewed very obliquely, as from R'' and L''. If the images of A and B fall on corresponding retinal points, the resulting sensation is binocular fusion, whether the visual lines be convergent, parallel or divergent; and the images of any

two points nearer or farther apart cannot fall on corresponding retinal points at the same moment with those of A and B, though small differences are easily neglected. Whatever may be the importance therefore of optic convergence, as a factor ordinarily in determining the binocular judgment of distance, it has no such exclusive and measurable value as that attributed in Brewster's experiments; and the apparent distance of objects viewed through the stereoscope is obviously not determined by intersection of visual lines, if conditions are such as to render these parallel or divergent. The visual effects of optic divergence can be more conveniently studied by using stereographs than by the method already described, and a modification of Wheatstone's reflecting stereoscope affords the best means of measuring variations of the optic angle. As the lenticular stereoscope, however, is now almost universally employed, it is important that this instrument, as found in the market, be examined first.

By diminishing the natural convergence of visual lines, the stereoscopic effect of binocular relief can be quite easily obtained, while gazing upon a stereograph, without any instrument, when the interval between corresponding points of the two pictures does not exceed that between the observer's optic centres. This distance does not often differ very much from 64 mm., which may be taken as an average value. In Fig. 3 the distance between the two central dots is 50 mm. If the reader will fix his gaze upon a point ten feet off, just visible below the edge of the page, and then suddenly raise the visual lines to the figure without changing their convergence, he will see three circles instead of two; the central one moreover will appear as the base of a cone whose vertex is pointed toward him, but capped with a small circle. A little attention then will reveal the fact that when the dots are seen distinctly and singly, the small circle is double and slightly indistinct, and *vice versa*.

On stereographs, however, the interval between corresponding points is always greater than 50 mm. As the result of measurement made upon the foreground intervals of 166 cards, European and American, taken at random, the mean value I have found to be 72.9 mm., the maximum being 95 mm. If binocular combination is secured without

FIG. 3.

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the stereoscope, therefore, optic divergence is nearly always necessary. To ascertain the extent to which this is counteracted by the semi-lenses of our best stereoscopes, 30 pairs of these were kindly loaned me by Mr. H. T. Anthony, of New York. With very slight variation, their focal length was found to be 18.3 cm., and their deviating power not sufficient to prevent the necessity of optic divergence, when the pictures are binocularly regarded through them, if the stereographic interval exceed 80 mm. As this limit is not unfrequently exceeded, optic divergence is often practiced unconsciously in using the stereoscope. Every oculist is familiar with the mode of using prisms to test the power of the muscles of the eyeballs, for both convergence and divergence of visual lines, and knows that 4° or 5° of divergence is not uncommon. Helmholtz (3) refers to the use of stereographs for the same purpose.

But familiar as is the production of optic divergence by artificial means, little or nothing seems to have been written in regard to the modification which the possibility of it imposes upon the theory of binocular perspective held by both Wheatstone and Brewster, accepted by most writers on vision since their time, and abundantly reproduced in our text books on Physics.* Of these I have not been able to find one that gives any account of the stereoscope except on the hypothesis that the visual lines are made to converge by the use of this instrument. On the uncertainty attached to the judgment of absolute distance from convergence of visual lines alone, Helmholtz (4) has written more fully than any one else. It is unfortunate that no English translation of his masterly work on Physiological Optics has ever been published. Although he gives no analysis of the visual phenomena produced in binocular fusion by optic divergence, his discussion of the judgment of distance would certainly tend to cast some doubt upon the explanation of vision through the stereoscope, as found in our text-books. And yet Helmholtz himself employs Brewster's theory in his mathematical discussion (5) of stereoscopic projection. This discussion, on the data assumed, is a model of elegance; but it contains no provision for divergence of visual lines. It is strictly applicable to the conditions involved in taking photographs with the binocular camera,

(3) Helmholtz, Optique Physiologique, pp. 616 and 827.

* Nov. 15th. Since the above was put in type, I have received from Prof. C. F. Himes, of Carlisle, Pa., an article written by him in 1862, in which he mentions his successful attainment of binocular vision by optic divergence, and criticises Brewster's theory of distance in relation to the stereoscope. Though his observation was independent, as my own was also, I find that he was preceded by a German, Burckhardt, in 1860 or 1861. I have already referred to Helmholtz in this connection (*Am. Journal of Science*, Nov., 1881, p. 361), and therefore have claimed no priority in discovering the possibility of this unusual, but still voluntary, employment of the eyes. It is the more remarkable that in our text-books the assumption should be so universal, that convergence of visual lines is a necessity in binocular vision for the determination of the apparent point of sight.

(4) Idem, pp. 823, 828.

(5) Opt. Phys., p. 842.

and to the projection of images viewed in the stereoscope when the convergence of visual lines is identical with that of the camera axes, but not otherwise. Instead of human eyes we may assume a pair of camera lenses, an interocular distance apart, and a pair of sensitized plates behind them. Helmholtz's formulas enable us to determine the stereoscopic displacements in the images projected. If proofs from the negatives thus obtained be inverted and placed in front of a pair of eyes in such manner that the visual lines passing through corresponding photograph points shall bear to each other the exact relation that existed between the secondary camera axes that terminated in them, these two points will appear as one, and nearly at the distance of the real point in space to which the camera axes were converged. The effect is much the same as if the eyes, with normal convergence of visual lines, had been substituted for the cameras. But if the proofs be too near together or too far apart, increase of convergence makes the whole picture seem nearer, while divergence makes it farther. The relation between the different parts having been fixed at the time the picture was taken, increased convergence makes the distance from background to foreground seem less, divergence makes it greater. No one can have failed to notice the gross exaggeration of perspective often seen in the stereoscope, when the pictures are so far apart as to make the visual lines parallel or divergent, while the angle between the camera axes, when they were taken, was relatively large. But in no case do these conditions cause variations of such magnitude as Brewster's theory of binocular perspective would demand. This is easily illustrated with Wheatstone's reflecting stereoscope.(6) Suppose the stereograph to represent a concave surface with the opening toward the observer, and that the arms of the instrument are properly adjusted. If they are pushed back, so as to make the visual lines divergent, the cavity apparently recedes and deepens; if pulled forward, so as to make them strongly convergent, it seems to approach and grow shallow. The apparent diameter of the image enlarges in the first case and diminishes in the second. Wheatstone notices this last variation in the account which he gave of his invention and its applications, in 1852, in the Bakerian lecture before the Royal Society (7); but, strange to say, the variation which is produced in apparent distance and depth under the same conditions seems to have escaped his notice, and the possibility of using his instrument to test the peculiarities of binocular vision with divergence of visual lines, seems not to have occurred to him. For the refracting stereoscope, however, like Brewster, he constructs a table of apparent distances corresponding to various optic

(6) For description, see Phil. Mag., s. 4, vol. III., June, 1852, p. 506.
(7) Phil. Mag., s. 4, vol. III., p. 504.

angles, and applicable in using the binocular camera for the purpose of taking slightly dissimilar pictures of the same object. He adds, (8) "when the optic axes are parallel, in strictness there should be no difference between the pictures presented to each eye, and in this case there should be no binocular relief; but I find that an excellent effect is produced, when the axes are nearly parallel, by pictures taken at an inclination of 7° or 8°, and even a difference of 16° or 17° has no decidedly bad effect. There is a peculiarity in such images worthy of remark; although the optic axes are parallel, or nearly so, the image does not appear to be referred to the distance we should, from this circumstance, suppose it to be, but it is perceived to be much nearer." This would not have seemed anomalous to Wheatstone, had he supposed binocular vision possible with divergence of visual lines, and entered into an analysis of the resulting visual phenomena. This analysis will be given in a future paper.

Oct. 31, 1881.

GENERAL SECTION.

The President, Dr. J. S. NEWBERRY, in the Chair.

Twenty persons present.

The following paper was read by Mr. JOHN H. FURMAN:

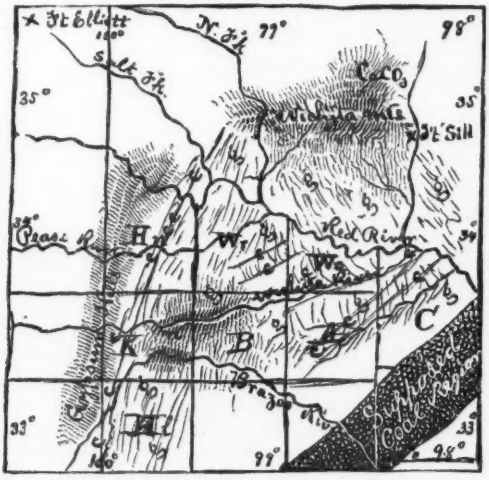
"THE GEOLOGY OF THE COPPER REGION OF NORTHERN TEXAS AND THE INDIAN TERRITORY."

The well-marked cretaceous beds of Parker County, Texas, extend for 30 miles north of west from Weatherford, on the road to Graham. They consist of strata of shelly limestone, sandstone and shaly clay, the latter grayish or reddish in color. An occasional thin seam of soft coal is found; and the water is strongly impregnated with lime. A stratum of sandstone stretches for thirty miles N. W. from Fort Worth. In this rock springs are found containing sodic carbonate, similar to the waters of the artesian wells of Fort Worth, Tarrant County, at a depth of about 270 feet. Towards Graham, the country assumes a semi-mountainous appearance, and, for twenty-five miles or more, sandstone ridges alternate with prairies, the hills being covered with scrub oak. Some of the ridges attain an elevation of two or three hundred feet above the prairies. The strata are horizontal, and large portions of the original surface have been carried away by erosion. The upper stratum is in many places a conglomerate, made up of small pebbles. In this region the seams of coal met with are generally soft, and the only workable

(8) Idem, p. 514.

bed known is one about three feet thick, yielding a fair quality of bitum inous coal, which crops out and has been traced for several miles near the Clear Fork of the Brazos river in Young County. This supposed coal region has a general N. E. and S. W. direction.

Approaching Graham the prairies begin to resemble the plains; and the ridges, capped with sandstone, show bases of mottled reddish-colored shales, or clay; salt springs and salt streams are found, indicating the border of the great alkaline region. From Graham to Fort Griffin in Shackleford County, thence north in Throckmorton County, the country rises. Every few miles a steppe is mounted, the face of the escarpments showing horizontal thin limestone strata. The same features continue, and then the country slopes towards the Brazos river.



SCALE—52 MILES TO 1 INCH.

A.	Archer County.	*Wa.*	Wichita County.
B.	Baylor County.	*Wr.*	Wilbarger County.
C.	Clay County.	*c. c. c.*	Copper Bed.
Hl.	Haskell County.	*g. g. g.*	Gravel Drift.
Hn.	Hardeman County.	*n.*	Narrows.

Turning westward through Haskell County, the surface lowers again towards the Brazos, the river coursing south to north, and a plain is crossed, the ground differing from any observed. The soil is mixed and covered with gravel, in many places several feet deep. The pebbles

vary in size from half an inch to an inch and a half in diameter, and consist of feldspar, quartz, porphyry, and basalt. On the western side of Haskell County the copper bed is reached not far from the Brazos river; and west of the copper a great belt of gypsum hills, several miles in width, extends northward, parallel with the copper bed, into the Indian Territory. Gypsum occurs there in most of its forms, including selenite which has been locally mistaken for mica.

On reaching a scene of attempted mining operations in search of supposed veins of copper, a very short examination convinced me that no vein would ever be discovered. Denudation has laid the bed bare, sweeping away the larger portion uncovered and leaving only patches; but these were sufficient to give a clear conception of the mode of occurrence. The copper-bearing stratum is an ashy-colored clay shale, more or less tinged with green, the upper portion showing the deep green carbonate of copper, usually two or three inches thick. Overlying this stratum is a cap-rock of gypsiferous sandstone, about three feet thick, with a layer ⅛ to ¼ inch thick, impregnated with carbonate of copper, as though it had soaked it up from below. Underneath the gray or green bed an intensely red clay shale is generally found. Nuggets of copper are scattered over the surface of the red bed, with pieces of cuprified wood and nuggets of iron pyrites. In the wood the original structure in many instances is perfectly preserved, also appearing cuprified in all stages of decay, as though it had become half rotten before the petrifaction was effected. The overlying sandstone frequently contains biscuit-like concretions of gypsum. Juniper trees abound and also cover the gypsum hills, the perfectly preserved cuprified wood, with its knots and bark, showing a fac-simile of that growth. I found in the gray bed fragments of wood partially unaltered, as though it had just commenced to absorb copper; also large pieces of coal, three or four inches or more in diameter, the cracks of the same piece being filled with crystalline carbonate of copper, or with white gypsum, thus appearing veined with copper and gypsum. In parts of the bed remaining the resemblance to piles of ashes and charcoal is strikingly deceptive. In one shaft, sunk to a depth of about thirty feet, the horizontal position of the strata was confirmed, the shaft passing through the cupriferous gray bed, and then through a succession of layers of red shale and soft red sandstone, in which not a trace of copper was found. The gray stratum extends seventy-five feet or more under a point of the gypsum hill. In a tunnel traversing this stratum I noticed occasionally pebbles belonging to the gravel drift. This copper formation has a general north and south course, usually less than fifty yards in width, and was traced for a distance of eight or ten miles to the southern boundary of Haskell County.

At one point the gray bed lies between beds of sandstone; the red bed does not appear, and the underlying sandstone strata are almost white, laminated, and very hard. The bed is more than two miles distant from the gypsum hills; the gravel drift is noticeable and even abundant. Observing the nuggets of copper ore and the drift pebbles lying about in places on the red bed, the idea forced itself upon me that there might be a remote connection between the two. However, the nuggets of ore are evidently concretions, and no pebbles occur in the gray bed. The gypsum range extends several miles across, with a western declivity similar to that on the eastern side. A plain, a little over one hundred feet below, reaches beyond to the foot of the great Llano Estacado. On these hills and on this western plain the gravel drift is wanting.

The copper bed was traced five miles further to the north: also in Knox county, not far from the Wichita river, and forty miles or more north of the southern portion of Haskell county: its occurrence was also reported north of the Wichita river. The copper band here lies between the sandstone and gray bed, with the red beds beneath. Eastward, between the Brazos and Wichita rivers, the gravel drift is abundant, with many stones of greater diameter. At the "Narrows," between the Wichita and Brazos rivers, the width is only sufficient to admit the passage of a single wagon. Continued caving in of the bluffs of the two rivers has widened an immense eroded area, rendering a large surface valueless, and while the channels of the rivers are several miles apart, their junction is only a question of time. In the copper region of the little Wichita river, near the centre of Archer county, the ore occurs under the same general conditions, with a different course, N. E. and S. W., and copper nuggets, coal and cuprified wood are found.

Embedded in the overlying sandstone, in some instances several feet above the gray bed, the sandstone frequently attains a thickness of more than fifteen feet. The cuprified wood is altogether different from that of Haskell county, and resembles the wood of the mesquite tree, which I found scattered about. The gravel drift here is identical in character with that of the region further west, and pebbles occur in the gray copper-bearing bed beneath the sandstone. The extension of the gravel drift of Haskell county, beyond the Brazos river system, its absence west of the gypsum hills, the larger size of the pebbles in Knox county, bordering the Wichita river, and the occurrence of the drift only in the vicinity of the copper-bearing lines mentioned, and in Archer county, suggested to me a possible relationship of some kind between the two, perhaps their origination in the same region. Between the Wichita and Pease Rivers I crossed several copper-bearing

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beds, having a general northeast and southwest direction. In Wilbarger County the gravel drift is in great quantity, and boulders from three to seven inches in diameter occur. In places, and having a northeast and southwest bearing, heavy deposits or lines of gravel and boulders attract attention, appearing as though a great flow towards the southeast had met obstructions along its course, the great incline of this region being directed toward the southeast. Beyond Pease River the gravel drift lessens, but the large boulders are occasionally seen as far west as the gypsum hills. Not far north from the centre of Hardeman County I again found the Haskell County copper bed, the accompanying sandstones being thin and much mixed with gypsum. The copper bed reaches higher than the surrounding country, except the gypsum hills to the west. From this high locality of the copper, known as Prairie-dog Mounds, the country inclines on one side northward to a creek emptying into Red River, and on the other side southward to the Pease River. South of these mounds, where only here and there patches of the bed are preserved in the midst of a general erosion, I found the largest mass of copper ore thus far discovered, consisting of an aggregation of cuprified wood, resembling the trunk of a tree, more than one foot in diameter.

Beyond Red River the bed continues to the vicinity of the Salt Fork of Red River, distant but little over 20 miles from the Wichita Mountains of the Indian Territory. The bed probably continues nearly to the western end of these mountains, and here must be found the true centre of elevation and the origin of the gravel drift. The Haskell County copper bed was also traced south to the Wichita River, thus establishing its continuity from the southern portion of Haskell County, through Knox and Hardeman Counties, into the Indian Territory, a length of more than 100 miles. Subsequently, the northern end of the bed was found a short distance from the western end of the Wichita Mountains, on the south side of the range. The copper formations of Archer and Wichita Counties continue through Clay County to the Red River boundary of the Indian Territory. The gravel drift does not extend to the north of the Wichita Mountains, but a limestone district occurs about 20 miles in width, that reaches probably as far out to the north, from the Wichita Range, the course of the latter being east and west. This limestone area may be called mountainous, is much disturbed and tilted, and is similar in appearance to the metalliferous limestone formation of Mexico. The Wichita Mountains are mainly made up of porphyries, trachytes and basalt, and appear to be two parallel ranges with transverse ranges and small valleys between. About 12 miles west of Fort Sill an extensive body of hornblende slate makes its appearance between the two main ranges. The drift from the mountains extends to the south and southeast. It is found as far west as the Haskell County copper bed, and as far east as the Archer County copper bed is known. The river channels of that section of the country have been formed since this drift period. The development of the Wichita Mountains seems to have marked the close of a period of uplift and simultaneous erosion.

These mountains have the same general appearance as the Rocky Mountains, which pass through the western portion of Texas and the State of Coahuila, Mexico; and it has been a matter of much interest to observe that similar drifts of local origin are frequently met in the latter regions. The Wichita Mountains appear to be identical in origin with the Rocky Mountains, and constitute the most eastern spur of that system. In Northern Mexico short ranges are encountered, striking east and west, and of these the Wichita Mountains appear to be a reproduction. The Wichita Mountains will be found to contain mineral deposits, possibly of some value; veins of copper ores do exist 40 miles west of Fort Sill, near Otter Creek, in the mountains; but I am convinced that the copper bed or stratum of Northern Texas will prove of no commercial importance.

DISCUSSION.

Prof. NEWBERRY remarked that the communication of Mr. Furman was of great interest, since no accurate description had before been given of the geological structure of the region where the copper occurs in northern Texas and the Indian Territory. He had received specimens from that region long ago and recognized their similarity to the copper ores of New Mexico, where in the upper portion of the Triassic formation copper forming concretions and replacing wood occurs in many localities, and has been more or less mined for. In one locality near Abiquini very extensive galleries have been cut in the sandstone in search of copper which there replaces branches and trunks of trees and forms concretions which are irregularly scattered through the rock. Here the work was done by the early Spanish explorers perhaps 200 years ago, and the remains of the furnaces in which the copper was smelted are still to be seen at the mouth of the mine. Still further west, in southern Utah, the same formation carries copper and considerable silver, at Silver Reef enough to pay well for mining, but in no locality yet known are the deposits of copper ore sufficiently concentrated and continuous to make mining for that material profitable; so it would doubtless be found in Texas and the Indian Territory. The copper was deposited with the Triassic rocks from a shallow sea in which an unusual quantity of copper was held in solution. This impregnated the sediments found at the bottom, replacing wood and forming as nodules about some nucleus. The aggregate quantity of copper in this formation was enormous, but, except where by the erosion of the beds it accumulated at the surface and could be picked up without any expense in mining, it would hardly pay to attempt to obtain it by ordinary mining processes.

The wood replaced by copper, Dr. Newberry said, was undoubtedly all coniferous, and different from any now living. The beds which contained the cuprified wood also contained much that was silicified. Of this he had examined many specimens under the microscope and had found the peculiar dotted cells which are characteristic of the coniferæ, and these grouped in such a way as to prove the trees to have belonged to the Araucarian group of conifers. So far as yet known the angiosperms, or higher order of plants, did not make their appearance on the earth's surface until after the copper bearing rocks of the southwest had been deposited.